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PATENT
Atty. Dkt. No. AMAT/4227.P1/DSM/BCVD/JW

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PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of: Latchford, et al.

Serial No.: 09/921,938

Confirmation No.: 8367

Filed: August 2, 2001

For: Photolithography Scheme Using A Silicon Containing Resist

Group Art Unit: 1756

Examiner: A.C. Walke

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Dear Sir:

APPEAL BRIEF

Applicants submit this Appeal Brief to the Board of Patent Appeals and Interferences on appeal from the decision of the Examiner of Group Art Unit 1752 dated May 6, 2002, finally rejecting claims 1-44. Applicant requests that the $320.00 filing fee for this brief, along with any additional extension of time fees under 37 C.F.R. §1.136 necessary to make this submission timely, be charged to Deposit Account No. 20-0782/4227.P1/DSM/BCVD/NAN.

Real Party in Interest

The present application has been assigned to Applied Materials, Inc., located at 3050 Bowers Avenue, Santa Clara, California 95054.

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Related Appeals and Interferences

Appellant asserts that no other appeals or interferences are known to the Appellant, the Appellant's legal representative, or assignee that will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

Status of Claims

Claims 1-44 were originally presented in the application and are currently pending in the application. Claims 1-44 stand rejected in view of references as discussed below. The rejection of claims 1-44 based on the cited references is appealed. The pending claims are shown in the attached Appendix.

Status of Amendments

Applicants submitted amendments to the claims in response the Examiner's final rejection in order to place the application in better condition for appeal and simplify issues on appeal that were not entered by the Examiner.

Summary of Invention

Embodiments of the invention provide a method for using a patterned amorphous carbon layer in a semiconductor stack as a hardmask during the etching of an underlying layer in the stack. The method of the invention generally includes forming the amorphous carbon layer (*see* Fig. 7A, 603) over the layer to be etched (*see* Fig. 7A, 602), and then forming a layer of a silicon containing photo resist (*see* Fig. 7A, 604) over the amorphous carbon layer. The photoresist is then patterned via conventional lithography processes (*see* Fig. 7A), and then the top two layers of the stack (the amorphous carbon layer and the resist layer) are exposed to an oxygen containing etchant (*see* Fig. 8A), as oxygen containing etchants are known to be effective etchants of amorphous carbon layers. The oxygen containing etchant operates to both etch the exposed portions of the amorphous carbon layer (the portions of the amorphous carbon layer that are exposed via the pattern formed in the resist layer), and to form an *in situ* resist layer hardmask in the outer portion of the resist layer. (*see* Page 21, Pgh. 71 and Fig. 8B, 609) This resist layer *in situ* hardmask operates to provide improved selectivity

between the resist layer and the underlying amorphous carbon layer, prevents resist layer erosion during the amorphous carbon etching process, and eliminates the need for the intermediate mask layers that are common in conventional multilayer resist processes used to etch amorphous carbon. (*see* Page 21 and 22, Pgh. 72) Once the amorphous carbon layer has been completely etched away in the resist patterned areas (*see* Page 22, Pgh. 73 and Fig. 9A), a second etching process is conducted using both the amorphous carbon layer and the resist layer having the hardmask formed into an outer portion thereof as a combined dual layer mask to etch the underlying layer. (*see* Fig. 9B) Thereafter, the amorphous carbon mask layer and the resist layer having the *in situ* hardmask in the outer portion thereon may both be removed by a third etching or cleaning process. (*see* Page 22, Pgh. 73 and Fig. 9B)

Issues Presented

1. Whether the Examiner erred in rejecting claims 1 – 7 and 36 – 42 under 35 U.S.C. §103(a) over *Babich* (U.S. Patent No. 5,830,332) in view of *Lin* (U.S. Patent No. 6,087,064).

2. Whether the Examiner erred in rejecting claims 10 – 14, 16 – 26, and 30 – 35 under 35 U.S.C. §103(a) over *Babich* in view of *Lin* and *Mitani* (U.S. Patent No. 6,191,463).

3. Whether the Examiner erred in rejecting claims 8, 9, 27, 28, 43, and 44 under 35 U.S.C. §103(a) over *Babich* in view of *Lin* and *Yang* (U.S. Patent No. 6,165,695).

4. Whether the Examiner erred in rejecting claims 15 and 29 under 35 U.S.C. §103(a) over *Babich* in view of *Lin* and *Sobczak*, and *Babich*, *Lin*, *Sobczak*, and *Mitani*, respectively.

Grouping of Claims

Pending claims 1 – 44 do not stand or fall together for the arguments presented herein. Applicants' first argument relates to the first issue for claims 1 – 7 and 36 - 42, and claim 1 is representative. Applicants' second argument has 5 subparts, and therefore, individual claims are representative of the respective subparts. The representative claims for the subparts of Argument II are as follows: a first subpart is

directed to claims 10 and 11 (which depend from claim 1), and claim 1 is representative; a second subpart is directed to claims 12 – 14 and 33 - 35, and claim 12 is representative; and third subpart is directed to claims 15 and 18, and claim 15 is representative; a fourth subpart is directed to claims 17 and 26, and claim 17 is representative; and a fifth subpart is directed to claims 19 – 25 and 30 – 32 (all of which depend from claim 17), and claim 17 is representative. Applicants' third argument relates to the third issue for claims 8, 8, 43, and 44, and claim 8 is representative. Applicants fourth argument relates to the fourth issue and claim 15 is representative.

ARGUMENT

I. THE EXAMINER ERRED IN REJECTING CLAIMS 1 – 7 AND 36 – 42 UNDER 35 U.S.C. §103(A) OVER *BABICH* IN VIEW OF *LIN*, AS THE CITED COMBINATION OF REFERENCES FAILS TO TEACH, SHOW, OR SUGGEST FORMING AN *IN SITU* HARDMASK LAYER IN AN OUTER PORTION OF THE PHOTORESIST LAYER.

Claims 1 – 7 and 36 – 42 stand rejected under 35 U.S.C. § 103(a) over *Babich* in view *Lin*. The Examiner has taken the position that *Babich* teaches a method for sputter deposition of an amorphous carbon layer for use as a mask to etch underlying layers, wherein the method includes depositing the amorphous carbon layer over the underlying layer, depositing and developing/patterning a layer of resist over the amorphous carbon layer, and then etching the amorphous carbon layer through the patterned resist layer to form a hardmask that may subsequently be used to etch the underlying layer. The Examiner has further taken the position that *Lin* teaches the use of a silicon containing photoresist layer. The Examiner then draws the conclusion that it would have been obvious to combine the photoresist of *Lin* with the method of *Babich* to generate Applicants' claimed method. Applicants appeal the rejection of claims 1 – 7 and 36 – 42 over *Babich* and *Lin*, and respectfully submit that the cited combination of references fails to teach, show, or suggest each of the limitations recited in claims 1 – 7 and 36 – 42, and further, that the references fail to provide any motivation to combine the photoresist of *Lin* with the method of *Babich*.

Applicants submit that *Babich* teaches a method for depositing a hydrogenated amorphous carbon layer that has optical properties sufficient to form UV and DUV attenuated phase shift masks. (*see* Column 2, Lines 38 – 45) The method includes depositing the hydrogenated amorphous carbon layer via a sputter deposition technique, and then patterning and etching the amorphous carbon layer via laser radiation or a reactive ion etching (RIE) process. (*see* Column 7, Lines 5 – 18) When an RIE process is used to etch/pattern the amorphous carbon layer, the etchant may be an oxygen containing etchant, as oxygen compounds are known to effectively etch amorphous carbon. (*see* Column 11, Lines 1 – 12) Once the amorphous carbon layer is patterned, the resist layer is stripped off the amorphous carbon hard mask layer. (*see* Column 11, Line 5) The resulting amorphous carbon hard mask layer is then used as a single mask layer to pattern to etch the underlying layer. However, *Babich* does not teach, show, or suggest forming an *in situ* resist layer hard mask in an outer portion of the photoresist layer, as recited in independent claims 1 and 36, the independent claims from which claims 2 – 7 and 37 – 42 depend.

Further, as noted in Applicants' specification at page 21, paragraph 72, the formation of the *in situ* hard mask layer provides several advantages not contemplated by the cited prior art. For example, the *in situ* resist hardmask provides for reduction of the erosion of the resist layer during the amorphous carbon patterning process, improved selectivity between the resist later and the underlying layers being etched, and elimination of intermediate mask layers required in conventional MLR processes. Further, the *in situ* resist layer hardmask also provides additional protection and added selectivity during the process of etching the layer underlying the amorphous carbon hardmask layer, as the resist layer is generally not stripped from the stack after the resist layer is used to pattern the amorphous carbon hard mask layer. (*see* Page 22, Pgh, 73) In comparison, *Babich* teaches away from this feature of the invention, as the resist layer is stripped off the amorphous carbon hardmask layer after it is used to pattern the amorphous carbon hardmask layer. (*see* Column 11, Lines 2 – 12) *Babich* notes that the resist layer is stripped from the stack as a result of the resist layer being substantially eroded after the first etching process and unusable for subsequent etching processes. (*see* Column 11, Lines 2 – 12) This is distinct from Applicants claimed

invention, as the *in situ* hardmask operates to preserve the photoresist, *i.e.*, the photoresist is not eroded by the oxygen containing etchant that is used to pattern the amorphous carbon mask layer. Therefore, the resist layer and the *in situ* hard mask layer formed into the outer portion of the resist layer may be used in the subsequent etching process (to etch the layer underlying the amorphous carbon mask layer) as an additional mask providing for an improved pattern and etch process that is not contemplated by *Babich* or *Lin*.

Lin teaches a multilayer lithographic method and an associated photoresist compound. The lithographic method of *Lin* is generally described as using a photoresist compound that includes a polymer component, an acid-sensitive crosslinking component, and a photosensitive acid generator. (*see* Column 7, Lines 58 – 65) The polymer component portion of the photoresist is described as having a silicon content of at least about 5 wt. %, and more preferably at least about 10 wt. %. (*see* Column 10, Lines 24 – 35) However, *Lin* does not teach, show, or suggest forming an *in situ* resist layer hard mask layer in an outer portion of the photoresist layer, as recited in independent claims 1 and 36, the independent claims from which claims 2 – 7 and 37 – 42 depend.

Therefore, Applicants submit that careful review and consideration of *Babich* and *Lin*, either alone or in combination, illustrates that the cited combination of references fails to teach, show, or suggest each of the limitations recited in independent claims 1 and 36. More particularly, the cited combination of references, either alone or in combination, fails to teach, show, or suggest the formation of the *in situ* hardmask layer in the outer portion of the resist layer. As such, Applicants submit that independent claims 1 and 36, along with the accompanying dependent claims, are allowable over the cited references and respectfully request the Board's consideration and reversal of the Examiner's final rejection.

Further, with regard to the Examiner's combination of *Babich* and *Lin* to support the rejection of claims 1 – 7 and 36 – 42 under 35 U.S.C. § 103(a), Applicants submit that the Examiner has improperly combined the references to support the rejection. More particularly, Applicants respectfully submit that the Examiner has failed to establish a *prima facie* case of obviousness under §103. To establish *prima facie*

obviousness of a claimed invention, all claim limitations must be taught or suggested by the prior art. (*see In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974)). Applicants submit that this requirement has not been met, as the Examiner has failed to indicate where either of the references teach or disclose the formation of an *in situ* hardmask in the outer portion of the photoresist layer, as recited in claims 1 and 36. Further, the Examiner is required to particularly identify the teaching, suggestion, or motivation from within the references to combine the references to generate the claimed invention. (*see In Re Dembiczak*, 50 USPQ2d 1614 (Fed. Cir. 1999)). Applicants submit that the Examiner has merely stated that it would have been obvious to combine the photoresist of *Lin* with the method of *Babich* to generate the *in situ* hard mask layer in the outer portion of the photo resist layer. (*see* both Office Actions) Since the Examiner has failed to identify any teaching, suggestion, or motivation from the references themselves to combine the references to generate Applicants' *in situ* hard mask layer in the outer portion of the resist layer, Applicants respectfully submit that the Examiner has failed to establish the requirements of a *prima facie* obviousness rejection, and therefore, the Board's consideration and reversal of the rejection is respectfully requested.

In addition to the above noted remarks, Applicants further submit that even if *Babich* and *Lin* were properly combinable, the cited combination of references still would not teach, show, or suggest each and every limitation recited in Applicants' claims. More particularly, *Babich* teaches that the photoresist layer is stripped from the stack after being used to pattern the amorphous carbon layer, which is completely opposite from Applicants' method where the photoresist is not stripped from the stack after being used to pattern the amorphous carbon layer. Applicants resist layer includes the *in situ* hard mask, which is not taught or disclosed in either of the cited references. This *in situ* hard mask allows Applicants' method to eliminate the step of removing the resist layer prior to etching the layer underlying the amorphous carbon mask layer, thus eliminating a step in the process (the step of removing the resist layer), as the resist layer and the *in situ* hard mask layer may be removed in a single etch or cleaning step that is used to remove the amorphous carbon mask layer. Thus Applicants' method provides elements that are not taught, shown, or suggested by the prior art (the *in situ*

hard mask layer formed into the outer portion of the resist layer), and also provides advantages over the methods of the prior art (eliminates the necessary step of stripping the resist layer from the stack prior to etching the layer underlying the amorphous carbon hard mask layer). Therefore, Applicants respectfully request the Boards consideration and reversal of the Examiner's rejection.

II. THE EXAMINER ERRED IN REJECTING CLAIMS 10 – 14, 16 – 26, AND 30 – 35 UNDER 35 U.S.C. §103(A) OVER *BABICH* IN VIEW OF *LIN* AND *MITANI* , AS THE CITED COMBINATION OF REFERENCES FAILS TO TEACH, SHOW, OR SUGGEST EACH OF THE LIMITATIONS RECITED IN THE RESPECTIVE CLAIMS.

Claims 10 – 14, 16 – 26 and 30 – 35 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Babich* in view of *Lin* and *Mitani* (U.S. Patent No. 6,191,463). The Examiner takes the position that *Mitani* teaches deposition of a thermally insulative silicon oxide layer onto a semiconductor substrate via a CVD process. The Examiner then concludes that it would have been obvious to one of ordinary skill in the art to combine the thermally insulative silicon oxide layer of *Mitani* with the teaching of *Babich* and *Lin* to generate the invention recited in claims 10 – 14, 16 – 26 and 30 – 35. Applicants respectfully request the boards consideration and reversal of the rejection in view of the following remarks.

Applicants submit that *Mitani* is directed to an apparatus and method for forming an improved insulating film on a substrate. The apparatus and method generally include using a CVD process to deposit a thermally insulating film, wherein the thermally insulating film is a silicon oxide layer.

SUBPART 1

With regard to claims 10 and 11, Applicants submit that *Mitani*, when taken in combination with *Babich* and *Lin*, fails to teach, show, or suggest each of the limitations recited in claims 10 and 11. More particularly, claims 10 and 11 each depend from claim 1, which has been argued above as allowable over *Babich* and *Lin* as a result of neither *Babich* nor *Lin* teaching the formation of the *in situ* hard mask layer in the outer portion of the resist layer that is recited in claim 1. Applicants submit that neither *Mitani*,

Babich, nor *Lin* teach, show, or suggest depositing and patterning a silicon containing photoresist layer over an amorphous carbon layer, and then etching the amorphous carbon layer through the patterned resist layer while forming an *in situ* hard mask layer in an outer portion of the resist layer, as recited in claim 1 (the independent claim from which claims 10 and 11 depend). Therefore, the Boards consideration and reversal of the Examiner's rejection is respectfully requested.

SUBPART II

With regard to claims 12 – 14 and 33 - 35, Applicants submit that *Mitani*, when taken in combination with *Babich* and *Lin*, fails to teach, show, or suggest each of the limitations recited in claims 12 – 14 and 33 - 35. More particularly, claims 12 – 14 and 33 – 35 are directed to the specific percentage of silicon in the silicon containing photoresist of the invention. Although the Examiner has cited to *Mitani* in order to supplement the teaching of *Babich* and *Lin* to reject claims 12 – 14 and 33 – 35, *Mitani* has no disclosure whatsoever of a silicon containing photoresist, nor any specific quantities of silicon in a photoresist. However, Applicants note that Examiner may have intended to refer to *Lin* with regard to claims 12 – 14 and 33 – 35, as *Lin* teaches a 3 component photoresist where one of the 3 components (the polymer component) has between 5 wt. % and 10 wt % of silicon therein. However, the manner in which *Lin* has defined the photoresist components, *e.g.*, three components that form the resist, wherein one of the three components has a specific quantity of silicon therein, makes the determination of what percentage of the entire photoresist is silicon (as recited in Applicants' claims) unattainable. Therefore, Applicants submit that the cited combination of references fails to teach the specific quantities of silicon in the overall photoresist composition, and therefore, Applicants submit that claims 12 – 14 and 33 – 35 are allowable. Further, Applicants submit that claims 1 and 17 (the independent claims from which claims 12 – 14 and 33 – 35 depend) are allowable as argued herein, and therefore, claims 12 – 14 and 33 – 35 are also allowable as a result of being dependent thereon. Thus, the Boards consideration and reversal of the Examiner's rejection is respectfully requested.

SUBPART III

With regard to claims 15 and 18, Applicants submit that claims 15 and 18 are directed to the method recited in claims 1 and 17 respectively, wherein the photoresist layer, the amorphous carbon layer, and the resist layer hardmask are all removed from the semiconductor stack via a single etching process. As discussed above in Applicants Argument I, *Babich* discloses a conventional MLR process, wherein the resist layer is used to pattern the amorphous carbon hard mask layer, and then the resist layer is stripped from the amorphous carbon hard mask layer prior to the etching process of the underlying layer. Further, *Lin* is primarily directed to a three-component photoresist, wherein one of the components includes silicon. However, *Lin* does not discuss the process of patterning the photoresist and the underlying layer, and more particularly, *Lin* does not teach, show, or suggest patterning a photoresist and an underlying amorphous carbon layer, forming an *in situ* hardmask in an outer portion of the photoresist layer, etching a layer underlying the amorphous carbon layer with both the amorphous carbon hard mask and the photo resist still overlying, and then removing the photoresist layer, the resist layer hardmask, and the amorphous carbon layer hardmask with a single etching process, as recited in claims 15 and 18. With regard to *Mitani*, as noted above, *Mitani* is directed to the formation of the thermally insulating silicon oxide layer. *Mitani* does not teach, show, or suggest a single etching process that removes a resist layer, an amorphous carbon hard mask layer, and a resist layer hardmask layer formed in an outer portion of the resist layer. Further, the cited combination of references in fact teaches away from this limitation, as the references teach removing the photoresist layer prior to etching a layer underlying the amorphous carbon hard mask layer. The photoresist must be removed in conventional processes, as the process of etching or patterning the amorphous carbon layer is known to degrade or erode the resist layer substantially. However, this is not the case with Applicants' method, as the *in situ* hard mask formed into the outer portion of the resist layer operates to preserve the resist layer, and therefore, allows Applicants' method to leave the resist layer intact through the etching process of the layer underlying the amorphous carbon layer. This feature then allows Applicants method to remove the resist layer at the same time the amorphous carbon mask layer is removed, which eliminates a

process step that was required in conventional processes. Therefore, in view of these distinctions, Applicants respectfully submit that the cited combination of references fails to teach, show, or suggest each of the limitations recited in claims 15 and 18, and as such, the Boards consideration and reversal of the Examiner's rejection is respectfully requested.

SUBPART IV

With regard to claims 17 and 26, Applicants submit that claims 17 and 26 each include the limitation of forming an *in situ* resist layer hard mask in an outer portion of the resist layer, which has been addressed above in both Applicants Argument I. Therefore, Applicants' remarks with regard to Argument I are also applicable to claims 17 and 26. Further, as noted above in Argument II, *Mitani* is generally directed to the formation of the thermally insulating silicon oxide layer is does not teach, show, or suggest any sort of resist layer hard mask formed in an outer portion of a resist layer. Claim 26 is directed to the specific thickness of the resist layer hard mask, and therefore, the cited combination of references also fails to teach, show, or suggest this limitation, as the hard mask itself is not taught by the references. Therefore, Applicants submit that the cited combination of references fails to teach, show, or suggest each of the limitations recited in claim 17, and as such, the Boards consideration and reversal of the Examiner's rejection is respectfully requested.

SUBPART V

With regard to claims 19 – 25 and 30 – 32, Applicants submit that each of these claims depends from claim 17, which has been argued as allowable above. Therefore, Applicants submit that each of claims 19 – 25 and 30 – 32 are also allowable as a result of being dependent upon an allowable base claim. As such, the Boards consideration and reversal of the Examiner's rejection is respectfully requested.

III. THE EXAMINER ERRED IN REJECTING CLAIMS 8, 9, 27, 28, 43, AND 44 UNDER 35 U.S.C. §103(A) OVER *BABICH* IN VIEW OF *LIN* AND *YANG*, AS THE CITED COMBINATION OF REFERENCES FAILS TO TEACH, SHOW, OR SUGGEST THE *IN SITU* RESIST LAYER HARDMASK THICKNESS RECITED IN CLAIMS 8, 9, 43, AND 44.

Claims 8, 9, 27, 28, 43, and 44 stand rejected under 35 U.S.C. §103(a) over *Babich* in view of *Lin* and *Yang*. The Examiner has taken the position that *Yang* teaches a method of making a semiconductor device using an ultra-thin later of photoresist, wherein the layer of photoresist has a thickness of 50 to 2000 angstroms, and therefore, the Examiner concludes that in view of the cited combination of references, it would have been obvious to generate the resist layer hardmask having the claimed thickness. Applicants respectfully submit that the cited combination of references fails to teach, show, or suggest not only the *in situ* resist layer hardmask formed into an outer portion of the photoresist layer, but also the specific resist layer hardmask thicknesses recited in claims 8, 9, 27, 28, 43, and 44. As such, the Boards consideration and reversal of the Examiner's rejection is respectfully requested.

Babich and *Lin* are discussed above, and as the Examiner notes, *Yang* teaches thicknesses of photoresist layers. However, claims 8, 9, 27, 28, 43, and 44 are not directed to the thickness of a photoresist layer, rather, each of these claims is directed the thickness of an *in situ* resist layer hardmask formed into the outer portion of the resist layer. None of the cited references teach, show, or suggest the *in situ* resist layer hardmask, and further, none of the cited references teach, show, or suggest a resist layer hardmask having a thickness of between about 75 Å and about 250 Å or between about 100 Å and 200 Å, as recited in claims 8, 9, 27, 28, 43, and 44. As such, the Boards consideration and reversal of the Examiner's rejection is respectfully requested.

IV. THE EXAMINER ERRED IN REJECTING CLAIMS 15 AND 29 UNDER 35 U.S.C. §103(A) OVER *BABICH* IN VIEW OF *LIN* AND *SOBCZAK*, AND CLAIM 29 OVER *BABICH, LIN, SOBCZAK*, AND *MITANI* AS THE CITED COMBINATION OF REFERENCES FAILS TO TEACH, SHOW, OR SUGGEST REMOVING THE PHOTORESIST LAYER, THE RESIST LAYER HARD MASK, AND THE UNDERLYING AMORPHOUS CARBON LAYER VIA A SINGLE ETHCING PROCESS TO ESPOSE A PATTERN IN THE MATERIAL LAYER

Claim 15 stands rejected under 35 U.S.C. §103(a) over *Babich* in view of *Lin* and *Sobczak*. The Examiner has taken the position that *Sobczak* teaches a method of forming a semiconductor device, wherein an oxygen containing RIE process is used to remove a portion of a photo resist layer, in addition to removing the underlying layers in a single sequence. Therefore, the Examiner concludes when *Sobczak* is taken in combination with *Babich* and *Lin*, the cited combination of references teaches each of the limitations recited in claims 15 and 29. Applicants respectfully submit that the cited combination of references fails to teach, show, or suggest each and every limitation recited in claims 15 and 29, and therefore, the Boards consideration and reversal of the Examiner's rejection is respectfully requested.

Babich, *Lin*, and *Mitani* are discussed above, and *Sobczak* generally discloses a semiconductor stack fabrication process wherein an RIE process is used to etch an underlying layer masked by a photoresist layer. The RIE process is disclosed as etching the underlying layer while also removing a portion of the photoresist layer. However, neither *Babich*, *Lin*, nor *Sobczak* teach, show, or suggest etching an amorphous carbon layer through a patterned photoresist layer while forming an *in situ* resist layer hardmask in an outer portion of the photoresist, and then removing the photoresist layer, the resist layer hardmask layer, and the amorphous carbon layer (all in their entirety) via a single etching process, as recited in claim 15. Further, when the layers are removed, the pattern in the underlying layer is exposed, as recited in claim 29. The process disclosed in *Sobczak* is a conventional patterned resist etching process, wherein a portion of the resist is eroded during the etching process. However, this conventional process is distinct from the claimed invention, as the *in situ* resist layer

hard mask prevents resist layer erosion during the etching process of the hard mask layer (the amorphous carbon layer) and the underlying material layer. Then, once the material layer is etched, all of the resist layer hardmask, resist layer, and the amorphous carbon layer are removed with a single etching process, as recited in claim 15. In view of the lack of teaching, showing, or suggestion of this process by the cited combination of references, Applicants respectfully request the Boards consideration and reversal of the Examiner's rejections.

Conclusion

In conclusion, Applicants submit that the cited combination of references fails to teach, show, or suggest the elements of Applicants' claims. Specifically, Applicants submit that the cited combination references fails to teach applying an oxygen containing etchant to a silicon containing resist layer in order to form an *in situ* hard mask layer in an outer portion of the resist layer. This resist layer *in situ* hardmask operates to provide improved selectivity between the resist layer and the underlying amorphous carbon layer, prevents resist layer erosion during the amorphous carbon etching process, and eliminates the need for the intermediate mask layers that are common in conventional multilayer resist processes used to etch amorphous carbon.

In view of the above noted distinctions, Applicants respectfully request the Boards' consideration and reversal of the Examiner's rejections.

Respectfully submitted,

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APPENDIX

1. A method for forming a patterned amorphous carbon layer in a multilayer stack, comprising:

depositing an amorphous carbon layer on a substrate;

depositing a silicon containing photoresist layer on top of the amorphous carbon layer;

developing a pattern transferred into the resist layer with a photolithographic process;

etching through the amorphous carbon layer in at least one region defined by the pattern in the resist layer; and

forming an *in situ* resist layer hard mask in an outer portion of the photoresist layer.

2. The method of claim 1, wherein depositing the amorphous carbon layer comprises forming the layer with a chemical vapor deposition process.

3. The method of claim 1, wherein depositing the silicon containing photoresist layer comprises forming the layer with a spin on deposition process.

4. The method of claim 1, wherein etching through the amorphous carbon layer comprises exposing the amorphous carbon layer to an oxygen based etchant.

5. The method of claim 4, wherein the oxygen based etchant chemically reacts with silicon in the silicon containing photoresist layer to form the resist layer hard mask.

6. The method of claim 5, wherein the resist layer hard mask has a thickness of less than about 1000 Å.

7. The method of claim 5, wherein the resist layer hard mask has a thickness of between about 50Å and about 1000 Å.

8. The method of claim 5, wherein the resist layer hard mask has a thickness of between about 75 Å and about 250 Å.

9. The method of claim 5, wherein the resist layer hard mask has a thickness of between about 100 Å and about 200 Å.

10. The method of claim 1, further comprising forming a material layer on the substrate with a chemical vapor deposition process prior to forming the amorphous carbon layer.

11. The method of claim 10, wherein the material layer comprises at least one of silicon dioxide and silicon nitride.

12. The method of claim 1, wherein the silicon containing photoresist layer comprises between about 3% to about 30% silicon.

13. The method of claim 1, wherein the silicon containing photoresist layer comprises between about 3% to about 10% silicon.

14. The method of claim 1, wherein the silicon containing photoresist layer comprises between about 5% to about 7% silicon.

15. The method of claim 1, wherein the silicon containing photoresist layer, the amorphous carbon layer, and the resist layer hard mask may be removed by a single etching process selective to these layers and leaving an underlying layer on the substrate.

16. The method of claim 1, wherein the resist layer hard mask is formed during the etching process.

17. A method for patterning a material layer in a multilayer stack, comprising:

depositing an amorphous carbon layer on the material layer;

depositing a photoresist layer on top of the amorphous carbon layer;

developing a resist pattern transferred into the photoresist layer;

etching through the amorphous carbon layer in a patterned region defined by the resist pattern;

forming an *in situ* resist layer hard mask in an outer portion of the photoresist layer during the etching process for the amorphous carbon layer; and

etching through the material layer under the amorphous carbon layer using the patterned region etched into the amorphous carbon layer and the resist pattern.

18. The method of claim 17, wherein the steps of etching through the amorphous carbon layer and forming the resist layer hard mask are cooperatively conducted in a single chemical process.

19. The method of claim 17, wherein forming the photoresist layer further comprises forming the photoresist layer having a predetermined quantity of silicon therein.

20. The method of claim 19, wherein forming the resist layer hard mask further comprises chemically reacting the predetermined quantity of silicon with an oxygen based etchant used to etch the amorphous carbon layer.

21. The method of claim 17, wherein the amorphous carbon layer and the material layer are deposited using a chemical vapor deposition process.

22. The method of claim 17, wherein depositing the photoresist layer comprises using a spin-on deposition process.

23. The method of claim 17, wherein developing the resist pattern comprises utilizing a photolithographic development process.

24. The method of claim 17, wherein etching through the amorphous carbon layer comprises applying an oxygen based etchant to the multilayer stack.

25. The method of claim 17, wherein forming the resist layer hard mask further comprises reacting silicon in the photoresist layer with an oxygen based etchant used to etch the amorphous carbon layer to form a silicon oxide layer in outer portions of the photoresist layer.

26. The method of claim 17, wherein the resist layer hard mask has a thickness of less than about 1000 Å.

27. The method of claim 17, wherein the resist layer hard mask has a thickness of between about 75 Å and about 250 Å.

28. The method of claim 17, wherein the resist layer hard mask has a thickness of between about 100 Å and about 200 Å.

29. The method of claim 17, further comprising removing the resist layer hard mask, the photoresist layer, and the amorphous carbon layer to expose a desired pattern in the material layer.

30. The method of claim 17, wherein forming the resist layer hard mask comprises reacting a first substance in the photoresist layer with a second substance in a chemical etchant to form the resist layer hard mask in an outer portion of the photoresist layer.

31. The method of claim 30, wherein the first substance comprises silicon.

32. The method of claim 30, wherein the second substance comprises oxygen.

33. The method of claim 19, wherein the predetermined quantity of silicon is between about 3% and about 30% silicon.

34. The method of claim 19, wherein the predetermined quantity of silicon is between about 3% and about 10% silicon.

35. The method of claim 19, wherein the predetermined quantity of silicon is between about 5% and about 7% silicon.

36. A method for forming a hardmask in a resist layer, comprising:

depositing a silicon containing photo resist layer over a material layer;

developing a pattern in the silicon containing photo resist layer;

etching the material layer with an oxygen based etchant to transfer the pattern into the material layer; and

forming a hardmask layer in the silicon containing photo resist layer during the etching process.

37. The method of claim 36, wherein forming a hardmask later in the silicon containing photo resist layer comprises chemically reacting silicon in the resist layer with the oxygen based etchant to form a hardmask silicon dioxide layer in an outer portion of the resist layer.

38. The method of claim 36, wherein the silicon containing photo resist layer contains between about 3% and about 30% silicon.

39. The method of claim 36, wherein the silicon containing photo resist layer contains between about 3% and about 30% silicon.

40. The method of claim 36, wherein the silicon containing photo resist layer contains between about 5% and about 1% silicon.

41. The method of claim 36, wherein the silicon containing photo resist layer contains between about 5% and about 7% silicon.

42. The method of claim 36, wherein the hardmask layer has a thickness of less than about 1000 Å.

43. The method of claim 36, wherein the hardmask layer has a thickness of between about 75 Å and about 250 Å.

44. The method of claim 36, wherein the hardmask layer has a thickness of between about 100 Å and about 200 Å.